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Bud Selection. In this number we present two brief articles from a California journal, bearing on the improvement of the fruit orchards of that state through methods of bud selection. A third article on this phase of plant improvement is a report which Mr. A. D. Shamel has written as a result of his studies in Hawaii during the past few weeks. He deals with the question of isolating superior strains within our standard varieties of sugar cane, and presents his opinion as to the practicability of such an undertaking.

Some Facts About Citrus Bud Selection.*

By C. S. Milliken.

Three years ago next May, the Fruit Growers Supply Company started the distribution of buds from superior citrus trees. Up to that time the selection of bud wood for propagation had been more or less casual. The results of Mr. Shamel's work demonstrated so forcefully the importance of bud selection, however, that the industry demanded more careful methods, so that at present some of the best groves in California have been selected, individual tree records kept, and the propagation bud wood is cut from these trees.

The object of this bud selection is not to create new citrus varieties. Its object is to take the very best in our present standard varieties and by budding from these sources, to make an improvement in our citrus plantings.

It is needless to say that bud selection is not the only important factor to be considered in the building of a productive orchard. Bud selection insures good parentage, but the offspring of good parents do not thrive unless they are properly nourished and grown in a salubrious environment. Bud selection is

*From The California Citrograph, May, 1920.

not a substitute for fertilization, irrigation, soil or climate. The point is that no matter how good the soil and climate, how pure the water, and how lavish the fertilization, productive trees cannot be grown from inferior parents.

There are many citrus growers who have discovered this in a very practical way—growers who have planted orchards propagated entirely from unproductive trees. After years of effort—fruitless effort—they are forced to rebud or to replant. Where good and poor trees are mixed throughout an orchard, as is most often the result of guess-work budding, the testimony of the unproductive trees is not so striking as where they happen to be segregated in unproductive blocks. Their effect upon returns is just as real, however, and if they could have been eliminated before planting, how different would be the record of the grove.

Bud selection should give us more productive orchards. What is the evidence? We will enter as exhibit one in the evidence, the young Lisbon lemon orchard at the Limoneira Ranch at Santa Paula. This orchard consists of trees in which there was a bud selection from the best trees in a good bearing orchard where individual tree records had been kept.

The older part of this young Lisbon orchard is now nearly seven years old, having been planted in the summer of 1913. In appearance it is one of the most uniform groves in the state, unquestionably the most uniform one that the writer has seen.

Individual tree records were not started in this orchard until June of 1917, when the trees were four years old. During the seven months of 1917, during which records were kept, the poorer lemon months of the year, the production averaged a picking box to the tree. The picking box holds about forty-three pounds of fruit. The next year, 1918, was the year of the hot spell which did so much damage to citrus crops. In 1918 these trees averaged two and three-fourths picking boxes per tree. In 1919 they averaged slightly over four picking boxes per tree. And it is to be remembered that Lisbon lemons have the reputation of being rather slow to come into bearing.[1]

The importance of bud selection is apt to be under-emphasized. To the average person an orange tree is an orange tree and a lemon tree is a lemon tree. It is generally known that in order to make these trees grow, they must be watered and fertililzed. But it is less generally known that in order that they may hang heavy with fruit of the desired type, they must have the right type of parent. The purpose of bud selection is to select parentage with care, a care in which guess-work judgment is replaced by a judgment based on accurately collected facts. The results of bud selection will be better orchards.

[1] We are informed that the product of a four-year Lisbon tree from an unselected bud is not more than five pounds per tree; a seven-year tree, one picking box.—H. P. A.

The Improvement of Sugar Cane by Bud Selection.*

By A. D. Shamel.

In response to your invitation I have completed a preliminary field study of the possibilities of improving sugar cane varieties through bud selection. My coming to Hawaii for this purpose was made possible through the sympathetic attitude of officials of the Bureau of Plant Industry, in which organization I am employed, and the Secretary of Agriculture, who granted me a special furlough for this purpose, making an exception in this case to the rule that employees of the U. S. Department of Agriculture are not loaned to private institutions.

During my stay here I have been able to make an unusually careful study of the condition of bud variation in several sugar cane varieties as a basis for the work of the improvement of these varieties through bud selection, by reason of your active personal cooperation and through the keen interest and helpfulness of several of your associates.

Our work has been carried on in the field by means of performance record studies of the behavior of individual sugar cane stools growing under commercial conditions of culture.

In these studies small plots of sugar cane were selected where the conditions were apparently uniform and in which the individual stools were growing under comparative environmental conditions.

In these plots both plant cane and ratoon cane were studied. In some cases the stalks were about one and in other instances approximately two years old.

Owing to the short time available for this work, it seemed necessary to confine these detailed studies to one or two varieties of leading commercial importance. It seemed apparent that the results secured from such studies, from which conclusion could be drawn, would be typical of similar work with all of the varieties grown in Hawaii. The careful and systematic work with a few varieties was thought to be preferable to a more general and less careful study of a greater number of varieties and covering a greater area.

In the course of these studies, performance record plot and individual stool studies have been carried on with H 109, Yellow Caledonia, D 1135, Big Ribbon, and Striped Tip varieties.

For the most part these studies have consisted of securing and recording individual stool data under the following heads: number, length, circumference and volume of stalks, length and number of internodes, condition of buds, lalas and tassels, weight of stalks, weight of bagasse, weight of juice, Brix readings of the juice, weight of sugar, and other notes descriptive of the stool conditions. These data were secured for each stalk in each stool in the performance record plots.

The position of each stool and of each stalk in each stool has been charted on cross-section paper, in some of the performance record plots, in order to show

*From a letter to the Director of the Experiment Station, May 3, 1920.

the location of each stalk, the stand of stalks, the arrangement of stools, and other important conditions.

This work was carried on by several men, each having a particular duty to perform. The selection of the varieties for the purposes of this study, the location of the performance record plots, and the method of work were all agreed upon after careful consultation and consideration. In locating the plots all possible care was exercised to secure uniform environmental conditions, in order that the differences in stool behavior could reasonably be ascribed to inherent differences due to bud variation, rather than to apparent soil differences, cultural or other conditions of the environment. The method of study and of recording the data was evolved as a result of experience in these studies.

From the fact that for the past twenty-two years I have been engaged in similar work—four years in charge of corn and other crop-breeding investigations at the Illinois Agricultural Experiment Station, seven years in charge of tobacco, cotton, asparagus and other breeding work with plants commonly propagated from seed, and eleven years with the investigation of the conditions of bud variation as the basis for the improvement of citrus and deciduous fruits through bud selection for the U. S. Department of Agriculture—the method of study pursued in these sugar cane investigations has been that with which we have been able to secure important commercial results in our previous work.

The results of the studies in the sugar cane performance record plots will be published in detail by the H. S. P. A. Experiment Station as soon as the tabulation of the data secured in the course of this work can be completed. In this way the exact results of these investigations can be considered by those who are interested in them.

From the fact that the results of our investigation will be published at an early date, no attempt will be made at this time to present any of the details of this work. It seems desirable, however, to summarize some of the results of our investigation in order that you and others may consider our conclusions while they are fresh in the mind.

Bud variations and mutations are of common occurrence in the sugar cane varieties. This is an established fact. My attention was first called to this condition in 1915 through a reference to these phenomena by Dr. R. S. Norris, at the San Francisco meeting of the American Association for the Advancement of Science, during the discussion of my paper on "The Importance of Bud Variation and Bud Selection in the Work of Crop Improvement." At his suggestion I secured a copy of the book "Cane Sugar," by Noel Deerr, in which the subject of "Bud Sports" is discussed on pp. 23–38. Later, other publications were secured, including The West Indian Bulletin, Vol. 2, No. 3 (1901 or 1902), where, on pages 216–223, the subject of "Bud Variation in the Sugar Cane" is discussed. In these publications numerous instances of sugar cane varieties arising from bud variation are cited and descriptions of these varieties given. In these discussions the color variations arising from bud variations are mainly considered.

From all available information it seems apparent that many of the sugar cane varieties of commercial importance in the world have been secured through the selection and propagation of bud variations. The records show clearly that

improved varieties of cane have arisen from bud variations in Louisiana, the West Indies, Mauritius, Australia, Hawaii, and elsewhere.

All authorities on record agree that bud variations in sugar cane are quite common and that plants grown from cuttings of the bud sports tend to reproduce true to the character of the sports.

Our studies here agree with these conclusions. While previous studies seem to have been concerned mainly with color variations, our investigation has forced us to the conclusion that bud variations in the sugar cane are not confined to color characteristics, but are also quite common with regard to other physical and chemical characteristics of the plants. It seems likely that color changes are frequently correlated with the size of stalk, number of stalks in the stool, weight of sugar in the individual stalks, and in the stools as a whole.

From the data secured, the tabulations thus far made indicate certain correlations of appearance and sugar content. It seems probable that a selection of stalks and of stools can be made from appearance, which will also show marked differences in sugar content and other characteristics.

Starting with the established fact that bud variations are of common occurrence in sugar cane varieties, this condition furnishes the basis for two phases of work of very great commercial importance to the sugar industry, viz.: (1) the origination of new varieties through the selection and propagation of striking bud variations, and (2) the improvement of established varieties through the isolation and propagation of the most valuable strains by means of systematic bud selection.

The first phase of this work will not be discussed at this time. The second phase, which I consider to be of the greater commercial importance, will be considered very briefly in this letter.

Our studies have clearly shown that in the varieties observed diverse strains exist, which have arisen through bud variations. The inferior strains have been propagated unintentionally by planters. The lack of a practical method of seed selection whereby seed from the stools of the best strains could be secured and seed from the stools of the poorer strains avoided, has resulted in the propagation of the inferior strains along with the valuable ones.

My observation has been that without selection in the propagation of any plants the inferior strains gradually increase in proportion to the good ones until eventually the population of the fields is largely made up of the undesirable strains.

On the other hand, my experience has shown that, with selection and propagation of seed or buds secured from the superior plants, it is possible to improve varieties so that the total population of the fields is largely made up of uniformly good plants. In this way, the selection and propagation of the best individual plants, the production and the value of crops can be definitely increased and improved without any increase in the cost of production other than that incurred in securing the seed or the buds.

The improvement of established breeds of livestock, and of established varieties of plants propagated from seed, has been carried on with very great success for a long time through the selection and propagation of the superior individuals within the breeds or the varieties. I believe that it has been clearly demonstrated

that most of the commercial progress in the improvement of livestock and crops has been effected in this way.

The agricultural crops, in which the plants are propagated vegetatively, or from buds, cuttings or grafts, have not been improved in the same degree as have the established breeds of livestock or seed crops. It is my conviction that the improvement of vegetatively propagated crops is a full half century behind that of animals or seed plants. This condition exists, I believe, because of the lack of knowledge of the condition of bud variation in such plants and the absence of practicable methods of bud selection which will take advantage of the development of superior individuals which originate as bud variations or bud sports.

Not many years ago many scientific men believed that such improvement was impossible. Today, all of the leading geneticists agree that not only is such improvement possible, but that it is probably of much greater commercial importance than we can now realize with our present inadequate knowledge of the phenomena of bud behavior. Slowly but surely facts are being accumulated which indicate the best methods of using and controlling the variations arising from bud-propagated plants in order to increase and improve our food supply.

My conclusions as to the improvement of sugar cane varieties through bud selection are: (1) marked improvement can be effected in the production of sugar by the established varieties through the selection and propagation of the superior stools; (2) in this work the quantity of sugar produced by the individual stools in a given field and growing under fair comparative environmental conditions should be given primary consideration. While color changes and other characteristics are interesting and significant, I am firmly convinced that the selection of mother stools should be based primarily on the quantity of sugar that they develop under field conditions. It is apparent that the quantity of sugar developed by a stool is clearly correlated with the number, size and weight of the stalks constituting the stools. Therefore, it seems logical that the stools producing the most sugar can be selected by inspection, securing seed from the stools having the largest number of large and heavy stalks with high sugar content. A necessary corollary to this statement is that in securing seed all stools with a small number of stalks or possessing small or light stalks with low sugar content should be avoided when cutting seed cane; (3) in selecting stools for propagation only those having uniformly large heavy and desirable stalks should be selected for propagation. The importance of uniformity of stalks within the stool may not be fully appreciated without actual experience in this work. One may think of it from several points of view. For example, take a human family in which there are several children of uniformly healthy, strong and well developed appearance. It is apparent to every one that in such a family we have good parentage and strongly developed hereditary characteristics. In the same way, thinking of the stool of sugar cane as a family made up of several stalks, the importance of uniformly desirable stalks in this family indicates to my mind the fact that in this family there is good parentage with highly developed desirable hereditary traits that may be prepotent and be carried on to succeeding bud generations.

In our citrus studies in California, and particularly in the securing of com-

mercial supplies of bud wood for propagation, only those trees are selected as sources of bud wood which are known to produce uniformly good fruits. If at any time during the performance records of these trees a single variable or off-type fruit is observed, those trees showing this condition are discarded as sources of bud wood. The results of this care in the selection of bud wood from superior parent trees of oranges, lemons and grapefruit are shown in several thousands of acres of fruiting orchards possessing uniformly good trees which produce uniform crops of fruit. This improvement in production in the citrus crops in California has already meant millions of dollars to the growers, in the opinion of those who have participated in and benefited from this work.

Similar beneficial results from the selection of superior parent plants in those crops which are vegetatively propagated have been secured in potatoes, a crop which in many ways, and particularly from the viewpoint of method of propagation, closely resembles the sugar cane. These results have been clearly established and demonstrated experimentally at the Cornell Experiment Station and commercially through the experience of many growers. For example, Lon D. Sweet, of Carbondale, Colorado, an extensive commercial grower of potatoes, has been able within a few years to improve the production of his Burbank variety, through the selection of uniformly good hills for seed, to the point where the value of his crop has been increased more than fifty per cent by reason of uniform size of tubers, and at the same time the quantity of tubers has increased more than fifty per cent by reason of the elimination of the poor hills. In other words, he has been able to increase the value of his crop more than one hundred per cent through the systematic selection of uniformly good hills for seed purposes.

In these investigations, seed cane has been secured and planted from both good and poor stools in each of the varieties studied. The behavior of the progenies will demonstrate the relative importance of some of the strains in each variety and the necessity for care in securing seed cane for propagation. A sufficiently large number of propagations have been made to show at an early date the possibilities of this work. Further selections should be made as opportunity permits in different locations, with more plantations, and with other varieties, in order that all of the facts be ascertained.

The commercial application of the principles of seed cane selection developed during the course of these studies include, in my opinion, the following considerations: (1) The selection of stools for propagation must be made by men with trained practical sugar cane experience and an intimate knowledge of the variety and its plant characteristics, gained from actual and first-hand work with the plants themselves. These men should have the farm point of view, which includes a quick realization of the economic side of farming. They should be careful and keen observers, who will develop that enthusiasm which will lead them to untiring effort in their field work. The importance of this work is such that, in my opinion, men can well afford to devote their lives to its study in order that they may become competent, truly expert, and achieve lasting and beneficent results for the sugar industry. (2) The work should largely be done in the field. No other methods of study will give really important economic results. From the fact that it is pioneer work, little or no published data is at hand concerning it. Therefore, it cannot be carried on from books; it must be done at first-hand

with the plants themselves. The men who are engaged must realize from the beginning the importance of serious, steady, and sustained effort. Like all other pioneer projects, its development will likely be attended with some difficulties. This condition seems to be a wise provision of nature to separate the weak and incompetent from the strong and competent. Valuable and lasting results are never easily achieved. They are the reward of patient, conscientious, enthusiastic, and sustained effort.

(3) Two kinds of work should be carried on. The experimental work, where the behavior of selections under comparative conditions can be studied, should be largely segregated and not be confused with the practical field work. This work can probably best be done in some of your Experiment Station fields. The selection of superior stools for propagation commercially should be done

Not more than two or three stools out of one hundred were suitable for seed purposes.

on each plantation. In this work it may be advisable from time to time to introduce seed from one plantation to another or from one district to another. In my opinion, such changes should only be made after the most careful consideration of all factors involved, although it may eventually become desirable to maintain seed fields in some districts of small plantations where reliable seed can be secured for planting by several planters.

(4) The securing of seed from superior stools should be done by those trained in this work. It seems likely that after standards are developed for the different conditions, many intelligent plantation laborers can be used for this purpose. Sufficient seed cane should be secured from the superior stools to plant an adequate mother field. This mother field, planted from the seed cane of the best stools in the established fields, can then be used for securing seed for general planting. It seems likely that if the first selection is carefully made, in which

probably less than one per cent of the total number of the stools in the fields are selected for propagation, the securing of commercial seed from the mother fields will be a relatively simple matter. A large percentage of the stools in the mother fields ought to be suitable for propagation. A gang of seed cutters can probably go through the mother fields and cut the seed from the good stools, avoiding only those showing markedly undesirable characteristics.

In the course of the study of both the general and the mother fields it is likely that a very few particularly superior, heavy, and desirable stools will be found. The seed from these distinctly superior stools should be carefully planted in a location where the behavior of the progeny can be closely watched, with a view to developing better strains.

I would like to recommend that when conditions warrant, a separate project be organized in the H. S. P. A. Experiment Station for the improvement of sugar cane through bud selection. This project should include both the experimental work and the commercial application of this work. The two lines should be kept separate, but yet carried on in one project, in order that both receive the benefit of the experience secured in the two lines of work. The men carrying on this work should do it exclusively, so far as possible, and be relieved of other duties which might interfere with the proper development of this project. Concentrated and continuous effort will be required during the entire year if the project is to be made a vital and necessary part of plantation practice.

The logical development of this project is likely to lead to other important and beneficial contributions to plantation practices in addition to that of seed selection. In the citrus, as a result of our bud selection studies, and based largely upon them, we have been able to discover fundamentally important methods of practice which are almost equal in importance to the bud selection work itself. I refer particularly to our study of the behavior of pruned and unpruned trees, and those pruned by different methods. This work was carried on as a part of our individual-tree performance-record work, and the results were such that they vitally affected commercially the practice of pruning in every citrus orchard in the state. Again, in the course of our work, the care of our trees in the performance-record plots led to the discovery and introduction of an improved method of applying manure to the soil, commonly called the furrow-manure method. At a recent conference of citrus growers, held in San Bernardino, California, February 20, 1920, the statement was made by one of the leading growers that the use of this method in California citrus orchards the past year was clearly responsible for the saving of one million dollars worth of plant food in the manure applied. Several other equally important results arising from these careful field studies could be mentioned, but the above are sufficient to show something of the possibilities of these first-hand studies, systematically carried on by sympathetic workers during a period of years.

(5) No public campaign of education seems necessary in the development of this project. The results speak for themselves. For example, let any plantation manager or other interested person cut one hundred successive stools from his best field, taking care to keep the stalks of each stool together. Lay these

stools out side by side, but distinct from each other, on a clear space where they can be examined. Go over these one hundred stools carefully and determine the number which from any point of view are apparently desirable for seed. In our studies these demonstrations have been particularly convincing. They have been carried on with one-year and with two-year-old stools, with plant cane and with ratoon cane. In any of the numerous cases studied thus far not more than two or three stools out of one hundred were suitable for seed purposes. Even the veriest novice must be led to this conclusion during such tests.

The mother fields should be, and I am confident will be, the strongest possible argument for care in seed selection. My observation is that farmers are intelligent men, more intelligent than they are usually given credit for being by those who do not till the soil. In fact I believe firmly that they are above the average in intelligence. My further experience is that when once a better method of growing crops has been clearly demonstrated for their particular conditions, they will quickly adopt such methods and make them a part of their regular operations. This particular work will demonstrate itself, and I am confident that amongst your plantation operators some men will contribute the most valuable information leading to its development and improvement, as has been the case with every other agricultural industry with which I have been identified.

(6) The exact methods of procedure will develop with experience. For example, the standards for stool selection, the number of stalks, their size and other characteristics, will likely differ in different regions having particular varieties, soil, cultural and other conditions of culture. The perfection of methods of selection is a matter of growth which will take care of itself if the necessary hard work, both physical and mental, is performed. The object of the work is clearly the improvement in production of sugar through the propagation of the superior strains and the elimination of the undesirable ones, through systematic seed selection from superior stools. If this ideal is kept clearly and continually in mind the results will come without question in my mind.

(7) The first selection is of the greatest possible importance. In my work so far I have observed that the greatest step was the first one. For example, in the isolation of strains of tobacco for growing under shade in the Connecticut Valley in 1903, one strain was fully isolated, which is now universally grown under the 10,000 acres of tobacco tent shade in that district. Another strain was isolated at that time, which is now universally grown under shade in Florida and Georgia. No similarly important steps have been made since, although great efforts have been made along this line. Similarly, in the isolation of the best strains of orange, lemon and grapefruit varieties in California, the director of the Citrus Experiment Station and others have repeatedly offered their opinion to me that the greatest step has been made that is likely to be achieved for many years, if ever. Therefore, in view of these and other similar experiences, it seems highly desirable to exercise the greatest possible care in making the first stool selections with sugar cane.

(8) Variation is continuous. This is one of the irrefutable facts in nature. While in the isolation of superior strains by the first selection of stools I believe that the greatest step will be made, I do not mean to convey the idea that the necessity for selection will stop there. Far from it! Experience in the development of strains of animals and plants shows unmistakably that continuous selection is necessary in order to maintain and improve the superior strains. However, after the strains of sugar cane have been isolated through selection, the work of selection within the strains is comparatively simple and practicable.

(9) In this work I cannot see how any loss is possible. If the best stools on a plantation are propagated on that plantation it is apparent to every thinking person that there is absolutely no possibility of loss, other than the small cost of making the selection. On the other hand, there is every probability of a large gain through more uniformly good stools from the superior parent stools propagated for the fields. The full force of the above statements can only be appreciated from an inspection of stools under field conditions as they now exist.

(10) A selection of individual large stalks will not secure the results. In many stools we find one large, heavy stalk and several small, light and inferior ones. It is apparent to any experienced person that the seed from the single large stalk in a generally inferior stool is not as desirable as the selection of seed from several uniformly large and good stalks in the same stool. Even if there is only one decidedly inferior stalk amongst several good ones in a stool, the seed from the good stalks is not likely to be as good as that from uniformly good stalks.

(11) This project can be carried out in Hawaii, where the industry is an organized one, much more efficiently than if the industry was in an unorganized condition. This phase is particularly apparent to those who have worked with both organized and unorganized agricultural industries. With an organized industry, such as the Hawaiian sugar industry, this work can be carried on quietly and efficiently. With unorganized industries much motion is lost in the effort to bring the results of any endeavor to the attention of the many individuals in it. Therefore, I believe that this work can be done in a business-like way here and with the greatest possible good with the maximum economy of effort.

(12) The expense of this project is likely to be very small in comparison with its results, from many points of view. In the citrus industry we have carried on our work with a very small cost, owing to the fact that the growers have furnished us every facility—including labor—without cost. This generous cooperation and spirit of contributing something to the welfare of an industry is not, I feel sure, confined to California citrus growers. From our limited experience with Hawaiian sugar cane planters, I am satisfied that they will respond quickly and generously to the appeal of this work, as a matter of public service, as the citrus growers have done. We have had the active help for days at a time of plantation managers, who have helped study stools of cane and who have shown unmistakably that they are willing and anxious to cooperate in this work to the fullest possible extent. All of such indications point to the fact that this project can be carried on with a minimum of cost as a whole. At the same time

the importance of this work should not be jeopardized by any false economy. The men engaged in carrying on this work should receive liberal salaries, such as is justified by the beneficial results of their efforts, which will be almost immediate and of larger consequence than may be realized at the present moment. Such men will develop a definite knowledge and technique which must be compensated for, as it is in other professions, by adequate salaries.

Personally, I want to express my sincere appreciation for your sympathetic cooperation in this investigation and the assistance rendered by your associates in carrying on this study. . . . .

I would like to close this letter by quoting from another letter, dated March 23, 1920, and which reached me after I had been in Honolulu about one month. It is from a gentleman who recently passed his eighty-seventh milestone. He is generally known in Southern California as the Dean of the Citrus Industry. Ethan Allen Chase was born in Maine, but at an early age went west to Rochester, New York. At Rochester he founded the Chase Brothers Nursery, and was one of the main factors in making Rochester the nursery center of America for more than half a century. He organized, in addition to his New York nurseries, similar institutions in Alabama and California. No one man has had more to do with the commercial development of our deciduous and citrus industries than Mr. Chase. He is a conservative man of unquestioned integrity, broad experience and successful endeavor. For the past twenty-five years he has made his home at Riverside, California. When I first came to California, in April, 1909, I began our first citrus bud variation and bud selection studies in some of his valuable orchards. Since then I have had almost daily contact with this noble and illustrious man. I give these facts in order that you may appreciate more fully the section of his letter which I now quote: ". . . I have no doubt you will get very much interested in the work (bud variation and bud selection with sugar cane), and there is not a particle of doubt but that you will find certain canes worth double others. The same is true in all vegetable, animal, and tree worlds. When I was a boy a cow was just a cow. We now know one cow is often worth two, producing better stock, more butter fat. In these times a poor cow has not much chance in a dairy. I believe that there is not a fruit producer of any kind that has not good strains and poor strains—currants, blackberries, grapevines, etc. You will find the same in what you are now looking for. Strange that when you first began to search for best citrus strains here men calling themselves scientists had no faith in it. But they have all had to give up. What a vast pile of work to find all the prolific plants and trees and the choicest of everything, and how strange that so very little has been accomplished through the centuries and that the truth of it should not have been realized till this day and generation."—(Signed) *E. A. Chase.*

This experience and opinion from one of the ablest and keenest men in all agriculture, who has achieved such lasting results for the development of the great fruit industries of America, is worthy of every man's thoughtful considera-

tion. For my part, I am absolutely convinced of the possibility of improving your sugar cane varieties through bud selection. It is practicable and can be made of immense economic importance to the sugar industry.

An Expansion of Bud Selection Work in California.

As evidence of the growing belief that crop improvement through bud selection is applicable to many species of plants, we learn from the California Citrograph that this work is now to be applied to a wide range of deciduous fruits. We read:

"The California Nurserymen's Association has become so impressed with the advantages of bud selection, largely through the work which has been inaugurated by A. D. Shamel of the U. S. Department of Agriculture in the citrus industry, that it has instituted a similar movement as applied to all nursery stock. . . . . For the first season the work will be confined chiefly to apples, peaches, prunes, cherries, plums, pears, apricots and almonds; and . . . . as there are practically no performance record trees available, ... during the early years bud wood will be cut simply from selected trees in bearing orchards. Commercial performance record work will be started just as soon as possible, so that eventually all bud wood sold by the association will be from record trees.

"Another line of work which this association will carry on will be the gradual elimination of some of the less desirable varieties of trees, so that a short list of acceptable varieties shall be agreed on as typical standard species. The association is also to set aside a fund for purely investigational work so that the services of such men as Mr. Shamel shall be available during the summer months. Questions of strains will be studied, and investigational work very similar to that conducted by Mr. Shamel in connection with citrus fruit improvement will be carried on.

"The California Nurserymen's Association is certainly to be congratulated upon its pioneer effort in this line. The money and effort will be well repaid and great good will come to the pomological and horticultural interests of California.

"The citrus fruit industry blazed the way and will always stand out as the leader in this fine undertaking."

[H. P. A.]

Progress in Sugar House Methods in Hawaiian Sugar Factories. *

By J. N. S. Williams.

Hawaiian sugar factories are noted for the keenness with which improvements in manufacture and production, whether original or acquired, have been put into effect. This is especially to be noted in connection with methods of extraction of sugar from the cane, in methods of producing commercial sugars, and in handling after products.

The most striking advances made in recent years have been in the direction of the extraction of sugar from the cane. The introduction of the Messchaert Groove in 1914, which is now generally used throughout this Territory, marked a period since which the advances made have been almost phenomenal. Previous to 1914 extractions of 96% or over were very uncommon, but in the year 1919 there were more extractions of 98% and 99% than there were in the year 1913 of 96%, and this advance in six years, to say the least, is very remarkable.

Interest having been centered on the subject of extraction, the losses in final molasses have not received so much expert attention, but nevertheless considerable progress has been made. In the report of the Committee on Manufacture for the year 1905, mention is made that Dr. Maxwell, the first Director of the Experiment Station of the Hawaiian Sugar Planters' Association, in his report for the crop of 1896, stated that an average of twenty plantations then reported upon produced a final molasses having a direct polarization of 35.4% and 46.5% apparent purity. In 1905 the average point to which waste molasses had been reduced was 30.14% direct polarization and 34.3% apparent purity, and this marked a very considerable improvement over what had taken place in previous years. As soon as competent attention was directed to the subject it was found that the purity of the final molasses, calculated from the direct single polarization and the Brix reading of the molasses, was not correct; the true percentage of sugar in final molasses, and also the true purity, was determined, and the following true purities were given in the Annual Synopsis of Mill Data made up and issued by the Experiment Station, H.S.P.A., in the following years:

In the year 1907 the true purity of final molasses averaged 42.65%
" " 1908 " " " " " " 44.00%
" " 1909 " " " " " " 43.74%
" " 1910 " " " " " " 44.83%

Comparatively few of the plantations, however, had the facilities whereby the average true purity of all the molasses thrown out during the crop could be made, and for the years 1911, 1912, and 1913 these averages are not given in the Annual Statements.

During this time a comparative figure which represented the true figure was developed by Mr. Noël Deerr, and is known by the term "Gravity Purity." This

* A paper presented at a special meeting of the Hawaiian Chemists' Association, April 15, 1920.

figure is determined by ascertaining the pure sugar in the final molasses by the Clerget method of double polarization, and the density of the molasses itself by the fractional method of spindling. These figures for gravity purity are shown as follows:

For the year 1914,	Gravity	Purity	of avge.	Final	Molasses	....	40.40%
" " 1915,	"	"	"	"	"	....	39.69%
" " 1916,	"	"	"	"	"	....	39.25%
" " 1917,	"	"	"	"	"	....	40.03%
" " 1918,	"	"	"	"	"	....	39.07%
" " 1919,	"	"	"	"	"	....	37.95%

Most plantations now render their accounts for the quality of the final molasses on the basis of gravity purity, and the above averages are taken from the results of some forty factories.

For the year 1914 the average of 40.40% given in the above table is made up of a maximum gravity purity of 44.9% and a minimum gravity purity of 36.32%, the difference between the maximum and minimum being 8.58 points; for the year 1919, when the average was 37.95%, the maximum was 43.06% while the minimum was 34.32%, showing a difference between the maximum and minimum of 9.28 points, which indicates that while some plantations had made practically no improvement in the work others had improved considerably.

On referring again to the 1905 report of the Committee on Manufacture, it will be found that very little was known then about laws which govern crystallization in low grade massecuites, but that it had been found that the apparent purity of tank massecuites should not be less than 45, and that the density to which the massecuites should be boiled should be high. Figures deduced from the results of crop 1905 at the Hawaiian Commercial Sugar Co.'s factory at Puunene show that the recovery of sugar from a massecuite varied with the density, and when the density was low (from 88 to 90 Brix) with an apparent purity of 44% to 46%, the sugar recovered from such massecuites would be considerably less than when the density to which the massecuite was boiled was from 94% to 96% Brix; which discloses the fact that even as long ago as 1905 it was known that the heavier low grade massecuites were boiled the greater was the yield of sugar, provided always that the grain was of such size and regularity that such massecuites could be dried and the sugar recovered.

In 1906 an attempt was made to increase yields of sugar from final massecuites by so treating the molasses mechanically that a large proportion of the gums which accumulate in end-products during factory operations are removed. After considerable experimenting it was found that while it was possible mechanically to remove these gums, and thereby increase the apparent purity of the molasses operated upon, no financial results were obtained by reason of any increase in the amount of sugar obtained from such massecuites, although it was noted at the time that molasses so treated, boiled more freely, grained more rapidly, and dried more easily in the centrifugals, but these advantages did not appear then to be commensurate with the expense involved in improving the quality of the molasses above mentioned, and therefore these experiments came to naught. Similar experience on similar lines was gained in Porto Rico at the Central Guanica, and more recently experiments have been made on these lines

in this Territory in connection with the clarification of mill juices, which have likewise yielded no material benefits.

During the year 1914 it was discovered that a so-called final molasses of low purity (38%–42% gravity purity), if boiled to a density of 98% to 100% Brix, developed as it cooled in tanks or cooler cars an immense number of very small grains of sugar. This seemed to indicate a field of original research, and a good deal of work was done, the results of which were reported upon in a paper read at the Annual Meeting of the Hawaiian Sugar Planters' Association in 1916, which gave the results of certain experiments and set forth a theory that it was not the gums or other substances in the molasses resulting from the manufacture of cane sugar which prevented the pure sugar in that molasses from crystallizing out, but the presence of water in the molasses, which retained the sugar in solution. This theory has been energetically attacked by foreign authorities, and an animated correspondence in the columns of the International Sugar Journal was carried on for some time; the question is yet debatable as to whether or not the said theory is strictly or only partially correct. That there is foundation for such theory is shown by the following facts:

Since 1914 a number of plantations have adopted the plan of boiling final massecuites to a density of from 96% up, running the charge so boiled into crystallizers or tanks to allow of graining, and when these massecuites are ready for purging they are passed through a pug mill and thinned down with a dilute solution of final molasses, and thereafter dried in the ordinary way in the ordinary centrifugal machine. This in many cases has produced an average final molasses of very low purity, as shown by the returns in the Annual Synopsis of Mill Data issued by the Experiment Station of the Hawaiian Sugar Planters' Association.

A further advance on this line has been developed by the Technical Staff of the Hawaiian Sugar Planters' Association, and consists in boiling very low grade molasses to a low water content and seeding the massecuites with a proportion of exceedingly fine grained sugar, whereby crystallization in this low grade massecuite is stimulated and expedited. This massecuite, however, is of such consistency, and the crystals of sugar are so minute, as to practically preclude the recovery of the said crystals by any machinery in general use at the present time. Small samples of final molasses from such massecuites have been obtained, which are practically free from crystals, and, as might be expected, the gravity purity of such molasses has been reduced considerably below anything hitherto known.

A sufficient amount of massecuite having been prepared at the Experiment Station, it was put through a special machine, with the result that nearly 50% of the pure sugar present in the original massecuite was recovered in the form of a dense high-purity massecuite, which is of a sufficiently high purity to allow remelting and working back with No. 1 massecuites. The density of the massecuite operated upon was 99.1 Brix, it had a purity of 44.5%, and was made from final molasses from a number of plantations which had a gravity purity of 35%, a sufficient amount of very finely grained sugar being added to bring it up to 44.5% gravity purity. The final molasses which was taken off was of a density of 88.55 Brix and had a gravity purity of 31.98, while the valuable massecuite remaining had a Brix of 96.7% and a gravity purity of 68.34. The

exact figures in connection with this test are being developed by the Technical Staff of the Experiment Station, but sufficient has been said to show that progress is indicated.

Great strides have been made in our factory work for many years, and many minds have been, and are, at work on the problem of securing sugar now lost in our by-products.

Whether or no we have arrived at a solution of the difficulties which beset us we cannot say, but at least we can assure ourselves that we are fairly on the way towards securing further gains of sugar now lost.

Seedling Sugarcanes.*

In his presidential address to the Royal Agricultural and Commercial Society of British Guiana, Professor J. B. Harrison, C.M.G., M.A., discussed the general outlook as regards seedling sugarcanes, with especial reference to their stability, and the manner in which their production is best undertaken. These remarks, embodying as they do the experience of one of the principal workers in this field of inquiry, extending over the whole period since the simultaneous discovery in the West Indies and Java of the seminal fertility of the sugarcane, carry very great weight; they are accordingly here reproduced in order to extend the publicity given to them. Professor Harrison said:

"In 1897 investigators generally were of the opinion that once a new variety of sugarcane was produced, that after its first period of excessive vegetative vigor had passed, its characteristics were fixed for all time. Soon after the cultivation of the new varieties had been extended over large areas, it became painfully evident to the majority of planters that their characteristics are not fixed, and that in many instances, characteristics which in the earlier years promised to make a variety of sugarcane of high value both in field and factory, were the first to fail. This tendency towards senile degeneration renders it necessary to raise new varieties of seedling canes year after year, in the hope of having fairly good varieties available to replace others which may gradually fail.

"Experience has proved to us that it is very easy indeed to raise new varieties of sugarcanes which are of high promise as plant canes. It has further proved to us that it is relatively difficult to obtain sugarcanes capable of producing good crops as plant canes and as first ratoons; and that it is exceedingly difficult to produce varieties which can be relied on to give satisfactory crops of plant canes, first, second, and third ratoons. Few indeed of the enormous numbers of new varieties which are now raised each year in various parts of the tropics will do this, and the problem of getting good varieties for cultivation under the long-ratooning system necessitated here by our deficient labor-supply and dependence on hand, instead of on mechanical, cultivation, becomes an exceedingly difficult one.

*Reprinted from Agricultural News, Vol. XVII, Sept. 21, 1918.

Elsewhere, with the exception of Cuba, sugarcanes are as a rule only cultivated as plants, or as plants and first ratoons. Hence, as the best varieties raised in Barbados, Java, and Hawaii have been chosen for their suitability for short ratooning periods, it is rarely that a sugarcane suitable for our long-ratooning conditions can be imported from elsewhere.

"The most successful method we have tried here for raising new varieties of sugarcane of promise is based on the facts that a sugarcane for successful cultivation on our heavy clay soils must be of well-marked vegetative vigor, and that whilst the range of variation in the saccharine-content of seedling sugarcanes is very great, its relative sugar-content is a fairly fixed characteristic of any variety. We endeavor to raise as many seedlings as we can from varieties of proved vegetative vigor, and select from them those having both well-marked vegetative vigor and relatively high saccharine-content. By this method we raised from D.625 the seedlings D.118 and D.419, the areas under which have increased from 2 acres and 1 acre, respectively, for the crop of 1911-12, to 2,710 and 1,360 acres, respectively, for this year's reaping.

"We have been advised time after time to give up our proven methods and to confine our efforts towards raising canes by cross-fertilization. If we had in this colony sugarcanes of single parentage showing fixed characters and, through their purity of origin, having little or no tendency to mutation or sporting, that advice would be excellent. In India, and to less extent in Java, sugarcane varieties of high purity of strain exist; and with these it is possible that by the application of Mendelian principles in raising seedlings, new varieties of high value may be obtained. Up to the present, however, this has not taken place.

"At the inception of the sugarcane breeding work here, Jenman was enthusiastic over the possibilities of raising new varieties of high promise by controlled methods of cross-fertilization, but in 1892-93 our hopes in that direction received a severe shock. Using a variety of sugarcane, the Kara-kara-wa cane, which our experience in three preceding years had shown to produce seedling canes having usually somewhat close resemblance to the parent variety, and placing it under conditions by which it was impossible for its arrow or flowering shoot to be either cross-fertilized by any other variety, or fertilized by any other flower shoot of its own kind, we got seedling canes from one arrow of 267 different sorts. The parent cane in its own seedling stage was hence possibly derived from fourteen diverse ancestral strains.

Supposing, for example, we take two kinds of sugarcane, one, X, having as ancestral kinds the varieties A, B, C, D, E and F, and the other, Y, derived from its ancestors A, B, G, H, I and J, it is evident that 406 different combinations can arise from the interbreeding of the two kinds, instead of a single blend or cross, X x Y.

"By Mendelian segregation, the inheritable properties of this diverse progeny will fall into three groups. We do not know which properties are inherited; but assuming that the general characteristics as a whole are heritable, the segregation of the seedlings from the cross X and Y may give rise in the first generation to 1,218 *groups* of varieties.

"Now either X or Y, by interbreeding with its own kind, could produce only 15x3 groups or forty-five general strains of sugarcanes. The complexity intro-

duced by the cross-fertilization of existent complex hybrids is well illustrated by this example.

"Up to 1902 we had not made any systematic attempt at raising canes of controlled parentage. We now do it as a matter of regular routine—not with any idea of getting seedlings having definite and desired characteristics, but as a means of greatly widening the range of their variation. We have complete proof of the success of the method in this line. Unfortunately, there is no chance in British Guiana of controlled cross-fertilization of the sugarcane proving a short and certain way to success in the production of new varieties of high saccharine value.

"Probably a more disappointing investigation has never been pursued than has been the search for improved varieties of sugarcane. There are now many stations at work at it in the tropics and sub-tropics; their results appear to be very similar. In the earlier years, working with natural varieties of sugarcane, several kinds of high promise are almost invariably obtained; in later years, when the mass of material for parental purposes has rapidly and enormously increased, the production of really good varieties appears to become increasingly difficult, and results satisfactory to both investigator and planter tend to be few and far between. It looks as though the good results arose from the unraveling of the complex ancestry of the natural varieties, whilst similar results from the re-tangling of the new strains thus obtained are comparatively rare, and are very elusive."

Those who are interested in the introduction of new seedling canes into their fields will, doubtless, in the light of these remarks, carefully consider the results which they are obtaining from their efforts. It will be observed that, in Professor Harrison's view, the work of finding promising seedlings is much more difficult when it is required to have canes that will ratoon well; when plant canes only are grown, the problem is relatively simple.

The question of the stability of seedling canes propagated by cuttings has long been under investigation. Some have held that these canes would prove stable, and indeed in the early days of the work this was the commonly accepted view; now, however, many are doubting this, and Professor Harrison appears to be amongst those who are convinced of the tendency towards early senile degeneracy on the part of these seedlings. It is observed that, in some districts where sugarcane is cultivated, there is a tendency to substitute one new seedling after another in the hope of obtaining ever increasing yields. Where adequate records exist, it would be well to examine these carefully, in order to see whether the newly introduced varieties retain their productiveness in full degree, or whether they fall off, so that the substitution of successive new varieties merely serves to maintain the sugar production at a high level, but does not tend to raise that level to the extent that is hoped and desired. Now that it is the commonly accepted practice on the majority of West Indian sugar estates to weigh the canes which are delivered to the large factories, and seeing that in the factories continuous analyses are made of the juice obtained from these canes, there should be in existence some data whereby it may be possible to learn something definite concerning the stability or otherwise of seedling canes during the years subsequent to their introduction into cultivation on a large scale.

Still the fact remains that the continued production of new seedling canes is a matter of moment for the sugar industry. This work affords means of combating many of the forms of fungus disease to which sugarcanes are liable, and it also affords the means of maintaining the level of production, even if it does not tend to raise that level so rapidly as was at one time hoped might be the case. It is therefore work essential for the well-being and development of the industry, and should be carried on continuously. [J. A. V.]

The Rat: A Plantation Menace.

By Donald S. Bowman.*

Rat extermination has received a great deal of attention on many of the plantations, owing to the great damage rats have done in the cane fields and through spreading the dreaded bubonic plague. There is no excuse for the rat's existence, as he serves no useful purpose in life and is a disease-carrying pest destroying thousands of dollars worth of cane each season. Every effort should be made to exterminate rats of all species. We should be able to recognize the different species and be familiar with their habits, and should have information as to what successful measures have been undertaken by others toward their extermination.

Species in Hawaii.

(*Mus norvegicus*) Norway or grey rat, which is readily identified by the large size, blunt muzzle and small ears and tail, the tail being shorter than the body and head. This rat is a burrower, living largely in gulches, stone walls, and cane fields. On the mainland this rat offers one of the most remarkable instances of successful usurpation to be found in the animal kingdom, it having driven the other species out of existence in many localities. This does not apply in Hawaii, as the black *rattus* and white-bellied *alexandrinus* are still in the majority. This conclusion is reached from a study of the rats caught in traps and may not be entirely correct owing to the fact that the Norway is the hardest rat to trap, he being the most sagacious and the most prolific breeder, having eight to ten young at a litter and breeding from three to six times each year. Its favorite diet is sugar cane, which is destroyed through gnawing. Some meat is required, which, when not easily obtained, leads to cannibalism.

(*Mus rattus*) Black rat; long known in Hawaii as the tree or house rat. It is black in color, smaller than the Norway rat, and of more elegant build. Its slim tail is longer than the body; ears are large; muzzle is long and pointed. It lives in trees, buildings, etc. It is less prolific than the Norway; its diet is about the same.

*Director, Industrial Service Bureau, H.S.P.A.

(*Mus alexandrinus*) Roof rat. In size, shape and habits similar to the black rat. He is lighter in color, with a white belly.

(*Rattus hawaiiensis*) Hawaiian rat. Described in Vol. III, No. 4, Occasional Papers, Bishop Museum. This rat is nearly extinct.

Destructiveness.

Exact figures as to the damage done by rats are not available, but the damage done to the cane fields alone runs into thousands of dollars each year. It is interesting to note that the cane growers of Porto Rico estimate their annual loss at $75,000.00. The estimated loss on the mainland amounts to $180,000,000.00 per year.

Disease Carriers.

Plague-infected rats have been trapped and found dead on the Island of Hawaii since 1900, and the history of the majority of the human cases of plague points to the transmission of the disease by plague-infected rats which were trapped or found dead on the premises where human cases occurred. Plague infection in the great majority of cases is flea-borne from rats to human beings, the fleas feeding on the plague-infected rat and then biting the humans. The India Plague Commission reports that plague is a disease of the rodent primarily and accidentally, and secondarily a disease of man.

Rat Destruction.

All known makes and devices for catching rats have been tried out by the plantations. The best all-around trap so far in use is a snap or dead-fall trap known as the "Official."

In trapping rats much depends on the trapper, as the traps must be properly cared for and placed, using the bait that will be taken. It is important that no other food in kind be available. It must be borne in mind that the kind of bait is of less importance to the rat than the matter of its availability. As a general rule bacon is the best all-around bait.

No poison exists that when eaten will dry up carcasses and prevent putrefaction or that may be relied upon to drive the animals from the premises to die. The brown rat when poisoned seeks its burrow, wherever located. A slow poison will usually allow it to reach this retreat, and thus is less liable than a quick poison to give unpleasant results in dwellings. This statement does not apply to the black rat or the roof rat nor to the common mouse, which are not burrowing species, but which usually live in the walls of houses. This accounts for the small number of dead rats of the Norway species found where poison has been placed in the cane fields and on gulch sides.

For poisoning rats or mice in open fields, at garbage dumps, on river banks, in warehouses, and in similar situations, the following formulas are recommended:

Strychnin (Sulphate) Formula:

Dissolve 1 ounce of strychnin (sulphate) in a pint of boiling water. Dis-

solve a heaping tablespoonful of dry laundry starch in a little cold water, add it to the strychnin solution, and continue to boil for a few minutes until the starch is clear. Add a scant teaspoonful of saccharin or a cup of thick sirup to sweeten the paste and stir thoroughly. Pour this mixture while hot over 12 quarts of clean oats in a metal tub and mix until all the grain is coated. Before using, let the grain stand until the coating dries. Occasional stirring will hasten the drying. Scatter the grain near rat burrows or runs.

Strychnin (Alkaloid) Formula:

Mix thoroughly 1 ounce of powdered strychnin (alkaloid), 1 ounce of common baking soda (bicarbonate), and ⅛ ounce of powdered saccharin. Put the mixture in a tin pepperbox and sift it gradually over 30 pounds of crushed oats in a metal tub, mixing the grain constantly so that the poison will be evenly distributed. Put out the poisoned grain about the rat burrows or runs, but not in piles of more than a teaspoonful.

Barium Carbonate Formula:

Barium carbonate for rats or mice may be fed in a dough paste of 4 parts of meal or flour to 1 part of the mineral. A more convenient bait is ordinary oatmeal (rolled oats) with about ⅛ of its bulk of barium carbonate, mixed with water enough to make a stiff dough. This may be exposed in bulk in a pan, or put out, about a teaspoonful at a place, in rat runs. Eaten in sufficient quantities this mineral is dangerous to all animals, and caution is needed in its use.

While most salts of barium are dangerous, barium sulphate, which is sometimes sold as a substitute for the carbonate, is not poisonous to rats or other animals.

Phosphorus Paste: (The prepared pastes on the market are the most practical and economical, "Stearns'" being the most generally used.)

Spread on stale bread sliced thin. Can be mixed with barley, cheese or other baits. This poison is endorsed by many as the best on the market, although it is expensive to use on a large scale.

A number of biological products have been sold as rat exterminators, including "Danyoz virus," "Ratin," and "Ratite," all of which have been tried out locally and the results of which do not warrant their use.

Rat-Proofing.

The slogan adopted by the U. S. Public Health Service, "Build the rat out of existence," should appeal to us all, for in this manner only can we keep our habitations free from rats. All dwellings and buildings where food supplies are stored should be made rat-proof. There should be no floors on or near the ground, and no double walls. All concrete foundations and floors should be surrounded by wing walls carried down to a depth of two feet.

A number of plantation villages have been made practically rat-proof through

raising all buildings two feet from the ground and doing away with double walls, etc. This work should be carried on until all settlements, especially in districts where plague is endemic, are made rat-proof, for in this way only will we be able to keep out the rat, thus lessening the danger of plague infection.

The rat-proofing will keep the rats away from the habitations and no doubt will reduce the rodent population in and near the settlements.

Rat Damage Might Be Reduced Nine-tenths.

From the Year Book of the Department of Agriculture for 1917 the following is quoted:

> To combat the rat successfully is largely a building problem. Buildings should be so constructed as to exclude the animals from shelter and food. When this is done, individual and community efforts to destroy rats will give satisfaction and lasting results. The program may be regarded by many as too expensive. Will it be too costly? What do rats cost now? If half the money now spent in feeding and fighting rats could be expended in wisely planned and well-executed cooperative efforts for rat repression, it would be possible within a few years nearly to rid the country of its worst animal pest, to reduce losses from its depredations by at least ninety per cent, and to free the land completely from the fear of bubonic plague.

Rat Eradication.

A report from the Japanese Government on anti-rat measures deprecates the value of trapping and poisoning as an anti-rat measure, contending that with the temporary reduction in rat population by these measures the relatively increased food supply and harborage stimulate breeding and longevity of rat life to a compensatory degree. Many other authorities hold that in thickly populated localities rat destruction is of little value. All, however, agree that rats can to a great extent be built out of existence.

The eradication of rats from our cane fields presents an entirely different problem. Here we have to deal largely with the Norway rat, the burrower who lives in or near the cane with an abundance of food. As it is not necessary for him to seek water, the cane juices supplying the needed liquid, living as he does on cane he is easily poisoned by other food baits, and when this occurs he seeks his nest, which accounts for the few found when poison is placed.

Plantations that have used poison to any great extent in the fields report good results, but in the minds of many it is a question of whether the expense involved warrants a field campaign.

In California, where an active anti-ground-squirrel campaign has been conducted for a number of years, splendid results have been achieved. As our field rat problem is the same, it would seem that the eventual results should be the same. It is evident that too much attention has been paid to the number of rats found dead and not enough to checking the lessened damage done to cane where active concentrated poison campaigns have been conducted.

RAT CAMPAIGN.

Where there is any great loss from destruction of cane by rats, it would seem good business to conduct an active concentrated field campaign of poisoning in a given section, checking this section against a like section where no campaign has been carried on. From the writer's experience in conducting extensive rat campaigns he is of the opinion that surprising results in cane saved will be proven. In districts where rat campaigns are conducted as anti-plague methods, the object is two-fold—first, to destroy the rat and drive him away from human habitation; second, to secure enough dead rats through either poisoning or trapping to ascertain by bacteriological tests whether or not plague-infected rats are present, thus keeping tab on the spread of the disease and being able to concentrate on rat destruction where plague-infected rats are found.

The Thomas and Petree Process for Handling Juice Settlings.*

The following is a short description of the method of procedure in working the Process for a treble crushing plant, where the thin juice obtained from the final crushing of the bagasse is returned as a maceration fluid to the first mill bagasse, and after this macerated bagasse has been crushed in the second or intermediate mill, water is applied to the twice crushed bagasse to form the final thin juice previously referred to.

The juice from the second mill (which contains most of the gummy and colloidal impurities expressed in the heavy second and later crushings) is preliminarily defecated and separately settled and decanted.

The resulting clarified second juice joins the first mill juice and this rich mixture is defecated and settled.

The rich mud from the settling of this mixed juice joins the second mill juice prior to it being preliminarily defecated and settled.

The clear juice resulting from the settling of the defecated mixed juice is sent to the evaporators.

A special mud formed from the settling of the second juice plus rich mud is returned to the bagasse at an early stage of the crushing without prejudice to the efficiency of extraction at the mills.

The returning of the rich mud or precipitate into the thin second crushing juice results in the whole of the solid impurities being ultimately withdrawn from the juice in the form of a mud, the liquid content of which is much lower in sugar than that of ordinary defecation mud.

The mixing of the flocculent rich mud or precipitate previously settled and consolidated with the second juice also assists in its clarification by enveloping and entrapping the gummy and colloidal impurities which are mainly found in the thin juices.

[R. S. N.]

*From a pamphlet, "Abolish the Filter Press," issued by the General Thomas and Petree Process Co. of Australia.

Alfalfa at the College of Hawaii.

At this time, when many plantations are undertaking the raising of alfalfa as a green forage crop for plantation stock, the work done at the College of Hawaii by Professor L. A. Henke along this line is of interest. From Bulletins 5 and 6 it is learned the Peruvian variety seems to meet the conditions in Hawaii, and gives splendid yields.

The yields of green forage on an acre basis since 1916 for the different varieties are as follows:

Variety.	1916. Yield in Tons of Green Fodder (Acre Basis).	1916. Number of Crops During Year.	1917. Yield in Tons of Green Fodder (Acre Basis).	1917. Number of Crops During Year.	First Half Year, 1918. Yield in Tons of Green Fodder (Acre Basis).	First Half Year, 1918. Number of Crops	July, 1918—June, 1919. Yield in Tons of Green Fodder (Acre Basis).	July, 1918—June, 1919. Number of Crops
Peruvian	37.07	8	40.78	9	22.13	4	33.82	9
Kansas	31.59	7	38.98	9	25.36	4	33.04	9
Arabian	47.50	7	38.12	9	27.50	4	45.80	9
Hairy Peruvian..	......	......	38.83	7	29.08	4	57.75	8
Utah	40.50	6	......	......	......	......	......	......
Australian	31.00	7	27.43	8	......	......	......	......

It is figured that the ratio of green forage to that of dry alfalfa hay is one to four, i.e., the above table represents weights that are about four times as large as the amount of dry alfalfa that would result if the green material were cured into hay.

It is pointed out that the cost of establishing a field of alfalfa is often high on weedy and rocky ground, but once established it needs very little further attention, and maintains itself many years. The College farm has several fields of alfalfa that are over three years old, and still producing well, as the above quoted figures show. It is possible to reduce the cost of establishing a new field in weedy ground by repeated discings so as to germinate and kill as many weed seeds as possible before planting the alfalfa. The alfalfa seedlings are very delicate for the first few weeks after coming up, and to hand weed an acre adds to the labor costs. It is planted in rows thirty inches apart, and cultivated and irrigated when necessary. The presence of nut grass in some fields has caused much trouble.

The following costs per ton are given for a yield per acre of Peruvian alfalfa of 54.88 tons green forage in 1916, and 41.95 tons in the same field for 1917:

	1916.	1917.
Man labor	$4.82 per ton	$2.23 per ton
Horse labor	.88	.58
Fertilizer	.33	.44
	$6.03 per ton	$3.25 per ton

The alfalfa is fed as green roughage to cattle and hogs, and in the form of cured hay to the horses. The feeding of green alfalfa in large quantities to working horses is considered too laxative in action, especially when cut before flowering. The same difficulty along this line is experienced to a lesser extent when fed to cattle, but is avoided by mixing with the green alfalfa sudan grass, sorghums, or sweet potato vines. [W. P. A.]

Kudzu.*

By Robert H. Moulton.

There are thousands of people in the cities throughout this country who grow climbing vines over summer house, front porches, pergolas and so forth, for shade or screening. For many years honeysuckles, moon vines, cinnamon vines, virgin's bower, Virginia creeper, or some other plant has been grown. But there is another climbing vine that is becoming very popular, and that is the kudzu plant. This is a perennial plant, and one of the fastest growers known. It makes a beautiful growth, the leaves being a dark green, and produces a dense growth providing a splendid shade. But the kudzu plant has another virtue and one that should place it ahead of any other climber today. That virtue lies in its value as a food for stock. It is richer in protein than alfalfa, and animals thrive on it. Although a perennial, the vines should be cut down to the ground each fall at the approach of winter. The heavy growth of even one vine will sometimes make more than one wagon load of good hay.

This remarkable vine gives promise of being one of the leading sources of wealth in certain sections of the country in the near future, especially in some of the southern states. It really is a pea vine that springs up from the roots when the first warm days come in the spring of the year and grows vigorously until a killing frost comes in the fall. This gives a growing season in some states of at least eight months in the year, during which several cuttings of hay can be made. Instances are known where four cuttings of hay, averaging ten tons per acre in a single season have been made. The hay is of the highest quality, being equal to cow peas or alfalfa and much richer than timothy.

The average analysis made by the state chemist of Florida, where the vine is now quite common, shows protein 17.43 per cent and starch and sugar 30.20 per cent, which makes it a somewhat richer food than wheat bran. Another remarkable feature is that although the hay is as rich a food as alfalfa it is entirely free from the tendency to cause loose bowels and bloat in horses and other livestock which interferes so seriously with the use of alfalfa. When moistened, kudzu becomes almost like fresh foliage again and makes an excellent green ration for poultry in winter. It is well adapted for use in making mixed feed stuffs and for all other purposes for which alfalfa can be used. The hay cures very quickly, retaining its leaves and bright color instead of shedding as cow peas

*The Field, Illustrated, January, 1920.

and velvet beans do; in fair weather only one day is required until it is ready to be put in the barn. For this reason it can be easily cured in the fields in stocks and under duck covers, thereby obviating the expense of building barns. Labor can also be saved by using sweep rakes instead of hauling the hay on wagons, after it has been cut with a mowing machine and raked into furrows with a common horse rake. Kudzu hay is worth from $20 per ton up, making the product of an acre yield $200 or over.

According to a number of authorities, kudzu is of even greater value for grazing purposes than for hay, since it requires no cultivation after the first season and will thrive upon land that is too poor and rough for any other crop. It has been found to do well on all types of soil from pure sand to the stiffest clay, provided the land is sufficiently well drained to admit of growing corn or velvet beans.

One planting of kudzu is permanent and the yield of hay increases as the ground becomes more thickly set with the vines, taking root at the joints. The great number of vines struggling for air and light creates a tendency to make them more slender and leafy, and thus improves the quality of the hay by eliminating any coarse vines, thereby enabling horses and other livestock to eat it up clean without any waste. The vines that run along the surface throw out roots at the joints, and these becoming new plants bind the soil firmly together, thus preventing the washing and erosion of hillsides by heavy rains. While this improvement is taking place the field is giving fine returns to its owner through the immense supply of rich forage on which the cattle, horses, and other livestock can graze. The result is that they are kept fat and in fine health at a very small cost for eight months of the year.

The roots of kudzu penetrate so deeply as to make it proof against any dry weather that is ever likely to prevail in most sections of the country. This feature and its peculiar habit of neither blooming nor bearing seed under field culture causes the vines to remain green and growing during the entire period from spring to fall. The hay can therefore be cut at any time that is convenient, when weather conditions are suitable for curing the hay, as kudzu is not injured by waiting for good weather as other hay crops are. This feature gives it an immense advantage over any other crop.

Kudzu is propagated by means of the plants that have rooted from the joints of the vines and when transplanted carry with them on their roots the tubercules that are needed to inoculate the soil of the new field. In planting kudzu the land should first be deeply plowed, then harrowed, and finally checked into rows 8½ feet apart each way, setting a plant at each check. Tap roots should be laid along the bottom of the furrow, with crowns slanting upward to within two inches of the surface, and then covered with loose earth to the level of the surface. This requires 1,018 plants per acre. One man and a boy can set several acres in a day. The man carries a shovel and opens up the holes by sticking it in the ground and pressing the handle forward, while the boy, carrying the plants, sticks them in back of the shovel. The shovel is removed and the man steps on each side of the plant to press the earth firmly, after it falls back on the plant.

The proper time for planting kudzu is two to three weeks in advance of corn planting, or a little earlier if one can get the ground ready. A full crop of corn

may be grown on the same land, the first year, by dropping the grains between the plants. Neither will interfere with the other and both need about the same attention, only the ground should be left smooth and level at the last cultivation to permit easy rooting of the vines or runners and subsequent mowing for hay. Plants cannot root so well on a rough surface.

After the first year the kudzu will not need any cultivation, as the vines will run all over the ground the second season and take root at the joints, growing so rapidly as to choke out all other plants, even such pests as nut, Johnson, and Bermuda grasses. At the same time it is an easy matter to get rid of kudzu if desired, for the plants will sprout only from the crowns and can be killed by cutting off the crowns with a disc plow in hot, dry weather in summer. For this reason there is no danger of kudzu ever becoming a pest.

Kudzu is perfectly hardy all over the United States and endures the winters as far north as Nova Scotia. It will, therefore, be a valuable crop in the northern states as well as in the south, although the longer growing season in the south is naturally an advantage. [H. P. A.]

The Effect of Concentration on the Deteriorative Activity of Mold Spores in Sugar.*

By Nicholas Kopeloff, S. Byall, and Lillian Kopeloff.[1]

It is common knowledge that the reduction of the moisture content of sugar is responsible for a diminution of deterioration. This is tantamount to stating that an increase in concentration of the films surrounding the individual particles in any given mass of sugar produces the same effect. The influence of this factor on the activities of bacteria has been the subject of thorough investigation by Owen,[2] and our recent work[3] with molds has led to the conclusion that "the factor of safety for sugars well infected with molds would appear to be lower than is generally supposed." The full import of such a consideration depends to a considerable degree upon the fact that molds may be responsible for the inversion of sucrose where only spores are present as well as when mycelia are developed. Furthermore, it has been shown[4] that the invertase activity of mold spores is ex-

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*Read at the 58th Meeting of the American Chemical Society, Philadelphia, Pa., September 2 to 6, 1919, and reprinted from The Journal of Industrial and Engineering Chemistry, March, 1920.

[1] Department of Bacteriology, Louisiana Sugar Experiment Station, New Orleans, La.

[2] Owen, Louisiana Bulletin, 162.

[3] Kopeloff and Kopeloff, Louisiana Bulletin, 166 (1919).

[4] Kopeloff and Byall, "The Invertase Activity of Mold Spores as Affected by Concentration and Amount of Inoculum." Read at the 58th Meeting of the American Chemical Society, Philadelphia, Pa., September 2 to 6, 1919, to appear in Jour. Agr. Res., February 15, 1920.

hibited at concentrations of sugar solutions varying from 10 to 70 per cent, with maximum activity at 50 to 60 per cent. In the same connection it was observed that an increase in the number of mold spores is responsible for increased invertase activity at any definite concentration—including saturated solutions. While these might be considered sufficient grounds for inference regarding the deteriorative activity of mold spores in sugars of known composition, it was deemed advisable to carry out such an investigation on a more practical scale.

TABLE I—SUMMARY SHOWING PER CENT INCREASE IN REDUCING SUGARS IN INOCULATED MOLASSES AFTER FOUR MONTHS' INCUBATION

Concentration	Cladosporium	Aspergillus flavus	Aspergillus S. Bain.	Penicillium expans.	Syncephalastrum	Aspergillus niger	Moisture ratio
Blackstrap	......	......	18.4	9.8	......	4.7	0.44
5/6 B. S. + 1/6 sirup ...	5.8	......	19.7	22.3	......	......	0.49
4/6 B. S. + 2/6 sirup ...	38.3	12.3	53.2	56.7	......	36.1	0.57
3/6 B. S. + 3/6 sirup ...	53.8	33.7	83.6	71.6	9.5	73.6	0.63

A series of sugars with films of known composition were made in the laboratory by coating large crystals of sterilized sugar with sterilized blackstrap molasses and 60° Brix sugar sirup in definite proportions, and purging in the centrifugal, a method previously employed with success.[5] These sugars and corresponding molasses were aseptically inoculated with mold spores by adding 15 g. of sugar containing approximately 1000 spores per g. (prepared as previously described)[6] to 135 g. of sugar in tightly corked Erlenmeyer flasks which were paraffined. The molasses was inoculated with a single scoopful of mold. Solid rubber stoppers, paraffined three times at short intervals, were later used. All flasks were incubated at 28° to 30° C.

In Table I is presented the summary of the per cent increase in reducing sugars over check as resulting from the inoculation of molasses by molds, all values representing the averages of closely agreeing triplicate determinations. These data will appear in greater detail in bulletin form.[1] It will be observed that with each mold used the per cent increase in reducing sugars is made greater with a decrease in concentration of the molasses medium at the end of a four-month incubation period. There was a corresponding decrease in sucrose Clerget in every sample. While this increase is striking, it does not follow a rigid mathematical progression, due to certain discrepancies which result from such a method of inoculation. It will be seen from Table I that *Aspergillus* Sydowi Bainier and *Aspergillus niger* exhibit the maximum inversion, closely followed by *Penicillium expansum.* This corroborates previous conclusions concerning the deteriorative activity of these organisms both in the mycelial and spore stage.[2]

Since such definite increases were obtained when molasses of known concen-

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[5] Owen, Loc. cit.

[6] Kopeloff and Kopeloff, "Do Mold Spores Contain Enzymes?" Read at the 57th Meeting of the American Chemical Society, Buffalo, N. Y., April 7 to 11, 1919, and printed in J. Agr. Res., [4] 18 (1919), 195.

[1] Kopeloff, "Biological Factors Affecting the Deterioration of Cane Sugar," Louisiana Bulletin (in preparation).

[2] Kopeloff, et al., Loc. cit.

trations were used, it might be expected that refined sugar coated with such different molasses would yield similar results. That this is practically the case may

TABLE II—SUMMARY SHOWING PER CENT INCREASE IN REDUCING SUGARS OF INOCULATED SUGARS AFTER ONE MONTH'S INCUBATION

Concentration	Aspergillus niger	Aspergillus S. Bainier	Penicillium expansum	Moisture ratio
Blackstrap	31.0	142.9	95.2	0.20
4/6 B. S. + 2/6 sirup	75.0	195.0	170.0	0.08
5/6 B. S. + 1/6 sirup	70.4	270.4	170.4	0.14
3/6 B. S. + 3/6 sirup	95.7	391.1	239.1	0.18
3/6 B. S. + 3/6 sirup	104.6	404.5	218.2	0.20

be judged from the data in Table II, which represents a summary of the per cent increase in reducing sugars over check as resulting from an inoculation with mold spores at the rate of 100,000 per g. after one month's incubation. It will be seen that an increase in moisture ratio

$$\text{M. R.} = \frac{\text{Moisture}}{100\text{—Polarization}}$$

which means a decrease in concentration, is responsible for raising the per cent increase in reducing sugars in most instances, except where blackstrap films were employed. The latter phenomenon may be accounted for by the fact that the molasses film was relatively thin, due to too prolonged purging. However, the other data, despite negligible discrepancies, are substantial proof of the direct effect of concentration on the deteriorative activity of molds. This has been proven to be a case of true inversion by the fact that an increase in reducing sugars has almost invariably been accompanied by a decrease in sucrose Clerget in the same sample. As in all previous work, *Aspergillus* Sydowi Bainier exhibits the greatest power of inversion.

If the results in Table II are compared with those presented in Table I, it may be noted that there was a greater deteriorative activity revealed in the former case where the moisture ratio was actually much lower. This would seem, upon the surface, to contradict the conclusion that a lowering of the concentration of the medium increases the deteriorative activities of molds. However, it must be remembered that the deteriorative activity of molds in any single medium is a resultant of at least two variables, *i. e.*, concentration and amount of inoculum. We have shown in another paper[1] that an increase in amount of inoculum is responsible for an increase in inversion in any sugar solution of definite concentration. That this principle applies to manufactured sugars is indicated here, for the inoculum used in Table II was approximately 100 times as large as that employed in Table I. Consequently, this experiment shows that a decrease in concentration causes increased deteriorative activity in mold-infected sugars, all other things being equal. Nevertheless, the effect of other variables cannot be overlooked. A similar experiment was repeated over a period of four months and the data gave similar evidence with moisture ratios varying from 0.18 to 0.29.

[1] Kopeloff and Byall, Loc. cit.

Considering the importance of the moisture ratio in predicting the keeping quality of sugar in storage under what is known as the "factor of safety" rule, it is of special interest to note that here is presented evidence of the deterioration of manufactured cane sugars with moisture ratios from 0.08 to 0.29 when sufficiently infected with mold spores; and, furthermore, that this deterioration occurs even in films of the highest concentrations, namely, of blackstrap molasses. In sugar solutions we have already arrived at the resultant effect of the combined variables of concentration and amount of inoculum. In other words, in saturated sugar solutions upwards of 5000 spores per g. are required to effect inversion.[1] We have experiments nearing completion which should establish similar criteria for sugar coated with films of known concentration as herein described. In this way it is our purpose to arrive at a satisfactory method of judging the keeping quality of a sugar from the standpoint of mold infection, which we have shown to be capable of inducing serious economic losses in sugar as a result of its deteriorative activity.

We wish to acknowledge our indebtedness to the Station staff for their kind assistance.

Summary.

1—A decrease in concentration of molasses inoculated with molds is responsible for a progressive increase in reducing sugars and a decrease in sucrose Clerget when incubated at 30° C. for four months.

2—A decrease in the concentration of films in inoculated laboratory-made sugars having films of known concentration and moisture ratios of 0.08 to 0.20, caused an increase in reducing sugars (and a decrease in sucrose Clerget) which gave evidence of active deterioration. These sugars were incubated at 30° C. for one month, and similar results followed a like incubation of four months.

3—*Aspergillus* Sydowi Bainier, followed by *Aspergillus niger,* and *Penicillium expansum,* in the order named, effected the greatest deterioration in both molasses and sugar.

4—There is evidence that an increase in inoculum is responsible for an increase in inversion at definite concentration. This investigation with laboratory-made sugars corroborates previous results obtained with sugar solutions.

[W. R. M.]

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[1] Koploff and Byall, Loc. cit.

Potassium Nitrate From the Chilean Nitrate Industry.*

By P. F. Holstein.†

Most of the information published regarding the possibilities of the production of potash in the Chilean Nitrate "Oficinas" and the present status of the question has been entirely general in character and at times misleading. The importance of this source of supply has been appreciated indeed by only very few of the nitrate producers themselves, yet during the war and at the present time several Oficinas (not more than half a dozen in all) manufactured a grade of nitrate containing a high percentage of potassium nitrate. Oficina Delaware of the du Pont Nitrate Company, a subsidiary of E. I. du Pont de Nemours and Company, has been the pioneer in this new development, which bids fair to be a factor of considerable value both to the nitrate producer and the potash consumer. The industry at the present time seems to be in rather a receptive mood as regards development of new methods, as is evidenced by numerous experimental plants, and it is very probable that the next few years will see the production of potassium nitrate in increasing quantities from the pampas of Chile. This article aims to present some of the main facts of the situation and to describe briefly the means actually at hand by which potash may be recovered.

During the year ending June 30, 1918, there were produced in Chile 64,340,267 quintals of nitrate (one quintal = 101.4 lbs.), or over six and a half billion pounds. The average potassium nitrate content of all the nitrate shipped is probably about 2 per cent, so that there were contained in this nitrate about 130,000,000 lbs. of potassium nitrate for which the producer received no additional profit. Calculated on a basis of K_2O this represents 30,000 tons of potash or about 21 per cent of the total consumption of the United States.

That this potash may be separated successfully and sold as a distinct product there is not the least doubt. This has been done since 1914 by a number of Oficinas and there are probably 100 more in the country that could do the same. Even if the price of potash should drop to the pre-war level there would still remain a substantial profit to the nitrate manufacturers, a fact of importance in meeting competition from artificial nitrate in years to come. The additional equipment necessary requires but a comparatively small outlay and should, in addition to the recovery of potash, have a definitely beneficial result on the percentage extraction of the ordinary nitrate. Moreover, this development occurs in an industry already established and accustomed to the handling and treatment of solutions on a large scale.

For many purposes there is a great advantage in the fact that this potash is in the form of nitrate, not chloride or sulfate. In this respect it differs from the potash from all other sources except the "East India Crude" product. It may

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*The Journal of Industrial and Engineering Chemistry, March, 1920.

†Assistant Administrator, Oficina Delaware, du Pont Nitrate Company, Taltal, Chile.

be refined readily to pure potassium nitrate, or used in fertilizers. The latter is a larger and more likely field. The product as turned out by the Oficinas would be a mixture of sodium and potassium nitrates containing from 20 per cent to 80 per cent of the latter salt.

The grade manufactured by any single plant depends primarily on the percentage of potash in the "caliche" or crude nitrate ore. An Oficina having 2 per cent to 3 per cent potassium nitrate in its caliche may easily recover potash in good quantity. The caliche of a majority of Oficinas will contain this amount and there are many having ore up to 5 per cent or even 7 per cent potassium nitrate. Those having a high percentage of potash in their ore have, of course, a great advantage both as to grade of product and as to cost of production. In fact, an Oficina having 5 per cent potassium nitrate in the ore may produce a certain amount of a marketable product high in potash at only a negligible cost above that of its regular sodium nitrate.

With ore of 3 per cent potassium nitrate a grade of high potash nitrate containing 25 per cent, 40 per cent, or 60 per cent may be made, depending upon the method of manufacture. An Oficina with a production of 50,000 quintals per month and an ore averaging 3 per cent potassium nitrate may divide this total production into approximately 40,000 quintals of ordinary nitrate and 10,000 quintals of "high potash" nitrate containing 25 per cent potassium nitrate, or 43,750 ordinary nitrate and 6,250 high potash nitrate containing 40 per cent potassium nitrate, etc. The production of this extra grade of nitrate will not as a rule add to the sum total in quintals of the "make" of the Oficina, but merely convert part of it into a more valuable product than ordinary Chilean nitrate.

The high potash nitrate is separated from the mother liquor resulting from the treatment of the caliche. The composition of the hot concentrated liquor that is run from the boiling tanks to the crystallizing pans varies with each plant, and from day to day at the same plant, depending upon the class of material being extracted. The two following analyses are more or less typical of Oficina Delaware, representing liquors obtained from caliches of between 2 per cent and 3 per cent of potash calculated as potassium nitrate.

	Hot Liquor	Mother Liquor
	(G. per 100 G. Water)	
Total Salts	146.61	90.99
Sodium Nitrate	100.04	40.95
Potassium Nitrate	20.87	19.96
Sodium Chloride	19.02	22.17
Specific Gravity	1.5050	1.4225
Temperature ° C.	74	9.5

There are many other salts in solution, such as sulfates, borates, iodates, perchlorates, magnesium, calcium, etc. The analyses given, however, are sufficient for this discussion.

The hot crystallizing liquor stands from five to ten days in the crystallizing pans during which time there is considerable air evaporation. This accounts for the fact that the weight of sodium chloride per 100 g. water has increased. For the same reason it will be evident that a small amount of potassium nitrate has deposited along with the sodium nitrate.

The important point is that the mother liquor is saturated at air temperature with potassium nitrate in a solution of many other salts. Very often the solution is saturated with potassium nitrate at temperatures much above that of the air, in fact as high in some Oficinas as 40° C. Under these conditions there will be deposited along with the sodium nitrate, on cooling, from 1 per cent to 10 per cent of potassium nitrate, and even more in a few plants exceptionally fortunate in the potash content of their ores. As the mother liquor is used over and over again in the extraction of fresh lots of ore it takes up more potash, depositing it in turn in the nitrate, except in cases where the potash is recovered and removed from the mother liquor before returning it to the plant. Referring to the above analyses it will be seen that if the hot liquor had contained 35 g. of potassium nitrate per 100 g. of water there would have been deposited about 15 g. when the liquor had cooled. As about 60 g. of sodium nitrate deposited, and the final product after deducting moisture, salt, insoluble matter, and sulfate is about 95 per cent nitrates, it is clear that the deposit would have contained about 19 per cent potassium nitrate. If the hot liquor had contained 25 g. potassium nitrate per 100 g. of water the deposit would have contained something over 7 per cent potassium nitrate.

This is exactly what occurs in the majority of Oficinas. The mother liquor, being used repeatedly through the boiling tanks for the extraction of fresh caliche, becomes rich in potash. The hot liquor as run to the crystallizing pans will not be saturated with potash, but on cooling will be saturated with this salt at a temperature above that of the final temperature to which the liquor cools. Hence the 1 per cent to 10 per cent of potassium nitrate contained in the product shipped from the Oficinas and sold as Chilean nitrate.

Fractional Crystallization—This suggests the first, simplest and cheapest means by which a nitrate containing a high percentage of potassium nitrate may be manufactured, available on any considerable scale, however, only for those Oficinas having a fairly high percentage of potash in their ores, close to 5 per cent calculated as potassium nitrate. Fractional crystallization will then give a commercially profitable high potash nitrate at an insignificant cost above that of their regular nitrate. The liquor when it has reached the proper temperature in the crystallizing pans is merely transferred to other pans where it cools to air temperature, this second deposit being the high potash nitrate. This method does not recover much of the potash in the ore, but does have the advantage of extreme cheapness and ease of operation and might be used immediately by a number of Oficinas which hesitate to install an expensive system. As long ago as 1912, Oficina Delaware recovered a small quantity of high potash nitrate regularly by this method, and one other company at least, to the writer's knowledge, recovered a certain amount by separating the crystals on top in the crystallizing pans. During the war several plants in Tarapacá produced high potash nitrate by fractional crystallization and are continuing to do so. There are undoubtedly many Oficinas which could make a certain quantity of high potash nitrate by this means, but are deterred, either by ignorance of the facts or by lack of a technical staff.

The fact that the mother liquor is saturated with respect to potassium nitrate, or at least contains a fair amount, gives two other methods by which it may be recovered, *i. e.,* evaporation or refrigeration.

Evaporation—By evaporation of the mother liquor there will result a solution concentrated in nitrate, and more or less of the character of the hot crystallizing liquor which is run from the boiling tanks, with the difference that the concentration of potassium nitrate is greater. As the solubility of sodium chloride in a nitrate solution is somewhat less at higher temperatures than in a cold solution, this salt is deposited during the evaporation. There is also, of course, a concentration of various impurities, magnesium salts, boric acid, iodates, etc. Fig. 1 gives cooling curves for a solution prepared by the evaporation of mother liquor. It will be observed that some boric acid is deposited, the nitrate manufactured by this method usually containing about 3 per cent. In operating practice it is usually better to return the mother liquor resulting from the evaporated liquor to the boiling tanks instead of mixing it with the regular mother liquor for evaporation. The liquors are thus "cleaned" of impurities by passing through the boiling tanks over fresh ore. It is also wise to regulate carefully the time of standing in the crystallizing pans, as otherwise the nitrate will be rather high in sulfate and magnesium, and, therefore, in moisture. Little difficulty will be en-

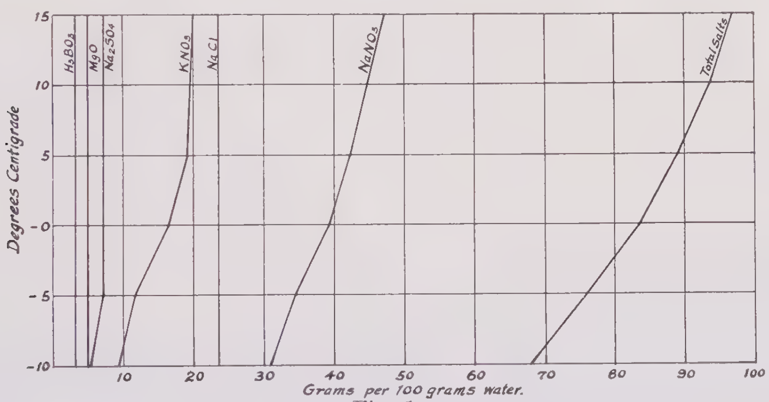


Fig. 1

countered, however, in producing a product containing 93 per cent to 95 per cent total nitrates, depending, of course, upon the potash content of the mother liquor evaporated. Oficina Delaware regularly produced a product by this method containing from 25 per cent to 30 per cent potassium nitrate, and several other Oficinas, having more potash in their ore, a higher grade.

It will be evident from the cooling curves that an evaporated liquor may be fractionated to give a fraction high in potash and a fraction relatively low. There is more or less difficulty in reducing the potash content of the first fraction low enough to avoid a large loss of potash, and unless there is an additional premium for the higher grade material that thus may be separated it is not advisable.

Refrigeration—The third method for the manufacture of high potash nitrate, *i. e.*, refrigeration of the mother liquor, has been in operation in Oficina Delaware since November, 1918, having superseded evaporation. This process is based upon the fact that the mother liquor is saturated with potassium nitrate at air temperature and that at lower temperature the solubility of potassium nitrate decreases more rapidly than the solubility of sodium nitrate. For instance, at 20° C. in the mother liquor there are approximately 55 g. of sodium nitrate and 25

g. of potassium nitrate per 100 g. water; at a temperature of —10° C. there are approximately 35 g. of sodium nitrate and 10 g. of potassium nitrate per 100 g. water, or in cooling through this range of temperature something over one-third of the sodium nitrate is deposited and nearly two-thirds of the potassium nitrate. In this particular instance 20 g. of sodium nitrate would be deposited and 15 g. of potassium nitrate. Assuming the product to be 95 per cent nitrates, the mixture would contain 40 per cent potassium nitrate. The mother liquor which gives a 25 to 30 per cent product by evaporation without fractional crystallization will give by refrigeration a product containing 40 per cent potassium nitrate.

Fig. 2 gives cooling curves for a certain mother liquor from 14° C. to —10° C. One of the main points to be observed is that no boric acid, magnesium salts, or chloride is deposited, and that sulfate did not precipitate until temperatures under —5° C. are reached. This is found to be true in practice, giving a much purer product than is obtained by evaporation. Below are given typical analyses of nitrate made by the two processes:

	High Potash Nitrate	
	Manufactured by Evaporation Per cent	Manufactured by Refrigeration Per cent
Moisture	3.72	0.79
Insoluble	0.10	0.09
NaCl	0.76	0.56
Na_2SO_4	0.44	0.35
Nitrate (by difference)	94.98	98.21
CaO	0.16	0.04
MgO	0.44	0.20
$KClO_4$	0.55	0.30
H_3BO_3	3.00	0.17
KNO_3	28.07	42.00

The greatest difference in the impurities is that of the boric acid, a fact that is of importance if the nitrate is to be refined for the manufacture of pure potassium nitrate.

By the addition of a small quantity of water to the mother liquor before refrigeration a nitrate very much higher in potash (60 to 85 per cent) can be produced in a single operation. This involves a great economy in case the nitrate is subsequently to be refined.

Exactly the same recovery of the potash, between 30 and 60 per cent, in the ore will be obtained by either evaporation or refrigeration. It is not entirely clear why more of the potash in the ore does not pass into solution, but the probabilities are that it is because it occurs in the caliche in the form of sulfate or difficultly soluble double sulfates or double salts. Some work has been done upon this subject with the hope of increasing the recovery and it is not improbable that a recovery may be obtained as good as that upon the total nitrate. The ordinary Oficina throws away daily in the tailings about 25,000 lbs. of potassium nitrate. Its recovery commercially is not, however, as simple as would appear at first thought.

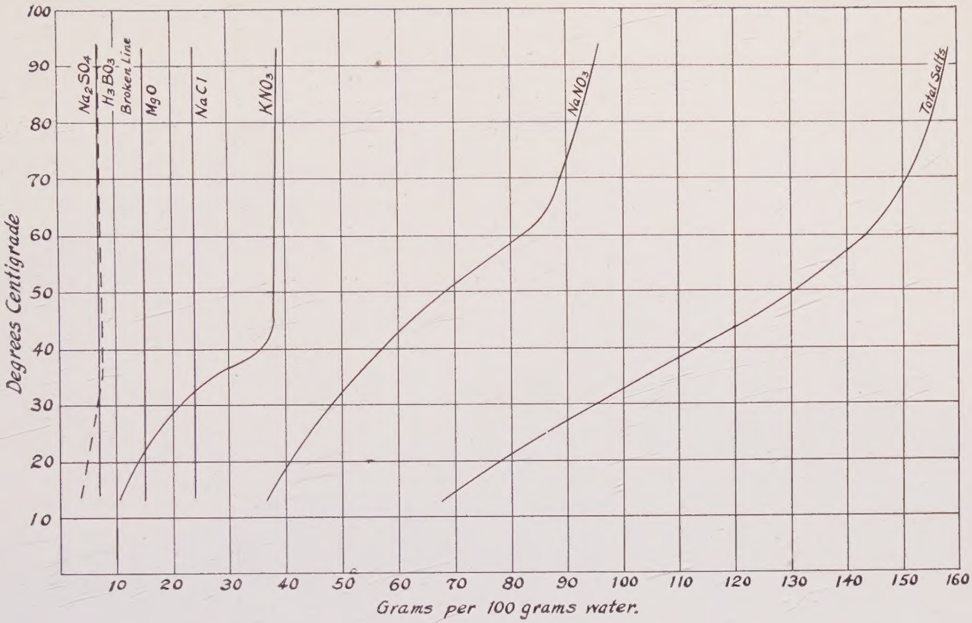


Fig. 2

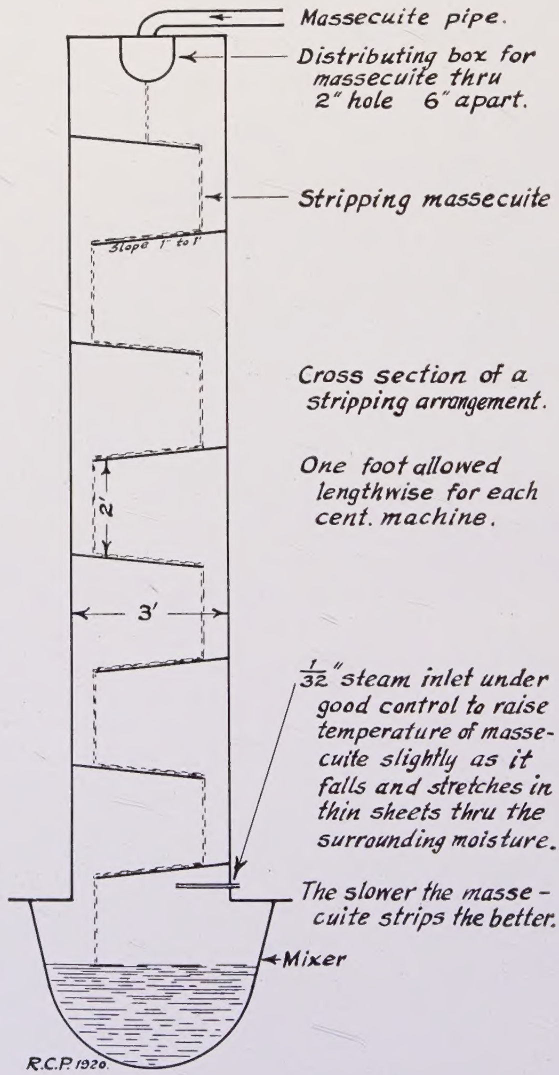
Whichever method for the recovery of potash an Oficina may choose, fractional crystallization, evaporation, or refrigeration, will depend a great deal upon their present plant installation and method of operation, and the conditions peculiar to their own particular plant. The character of the ore and its potash content, the air temperature in summer and winter, the composition of the mother liquor, and numerous other factors must all be given consideration. Refrigeration will produce a higher grade nitrate at a much lower cost than will evaporation. On the other hand, evaporation, if properly carried out in the right type of evaporator, has the advantage that the water removed from the system may be used as additional wash water for washing the tailings in the boiling tanks, thus increasing the recovery of sodium nitrate. The usual type of evaporator will not be found satisfactory because of the heavy precipitation of salts during evaporation. The tubes must be cleaned by washing and if the design of the evaporator makes necessary a large quantity of water for this purpose, considerable of the advantage that otherwise would be gained by driving off water from the system will be lost. Each Oficina should have its own solution as to which method will give the cheapest cost and the best results.

In the above brief discussion only those methods have been mentioned which have been tried on an actual operating scale. There are a number of other possible means, but the ones described are those which at the present time are giving satisfactory results in the few Oficinas that so far have appreciated the opportunity that they have for the manufacture of a valuable by-product. A number of the larger companies are giving serious study and consideration to this new development of the nitrate industry and a year undoubtedly will see a number of other Oficinas producing potash. [W. R. M.]

A Mechanical Aid to Centrifugaling Sugar.*

By R. C. Pitcairn.†

From some remarks made to me by Mr. W. R. McAllep, of the H.S.P.A., on the possibility and desirability of being able to change the viscosity of low grade massecuites of 98 to 99 density to a number of preparatory treatments before centrifugaling same (such as vibration, passing it between rollers, stretch-



Cross section, showing 8 strippings inclosed in 1" board housing, massecuite flowing over board strippers.

*Presented at a special meeting of the Hawaiian Chemists' Association, April 16, 1920.
†Chemist, Wailuku Sugar Company.

ing, passing it through a ¼″ mesh screen, and running it over a system of stripping boards), the best results were obtained by the stripping system, as I shall call it, although this could be modified and the same results obtained a number of other ways. This stripping process is exceedingly simple and consists of allowing the massecuite to flow by its own weight over a number of boards or plate baffles, set approximately 2 feet apart, one above the other, and stretching by its own weight into thin sheets of massecuite. I found that the oftener this was repeated the easier the massecuite purged, and so marked was this improvement that I am trying it now on a larger scale at Wailuku with beneficial results.

The stripped massecuite will give the same purity to the resultant sugar in the basket as the unstripped, in 25 to 35% less time, or in the same length of time it will show a decided increase in purity over the unstripped massecuite. The molasses comes off much faster in the earlier stages of centrifugaling on the stripped massecuite, provided the massecuite is kept warm during the stripping process. In other words, I am able to do in 40 to 45 minutes with the stripped massecuite what it would take an hour to an hour and a quarter with the unstripped, and I get only a slight raise, if any, in the purity on the resultant molasses. The above results I was able to substantiate by weighing the massecuite and the sugar left in the basket. On a high grade massecuite the improvement on the stripped over the unstripped is also marked.

The following figures will give a good idea of the benefits derived from this process:

NO. 2 MASSECUITE—BRIX 95.48, PURITY 46.92

	Time Spun	Temperature	Purity Sugar	Wt. Grms. Sugar	Wt. Grms. Massecuite	Purity Molasses	% Sugar on Massecuite	% Mol. on Massecuite
Massecuite direct from tank to centrifugal machine.	1 hr.	28° C.	66.45	781.5	1678	28.0	46.5	53.4
Massecuite stripped eight times	1 hr.	29° C.	75.83	555.5	1650	29.0	33.7	66.3
Massecuite stripped eight times	40 m.	29° C.	64.10	837.5	1678	27.9	49.9	50.1

The above results were a fair average of six tests made on an 8″ tightly sealed centrifugal machine, running 1,300 R.P.M., screen 00, and showed over 25% improvement.

Massecuite unstripped, spun 1 hr. 10 min. Temp. 29° C.

Massecuite	Brix 96.25	Purity 55.60
Molasses	" 92.55	" 33.50
Sugar	" 99.30	" 82.60

Massecuite stripped, spun 50 min. Temp. 29° C.

Massecuite	Brix 96.05	Purity 55.20
Molasses	" 94.65	" 33.80
Sugar	" 99.85	" 82.60

Massecuite stripped, spun 50 min. (steamed while stripping).
Temp. 35° C.

Massecuite	Brix 95.75	Purity 54.80
Molasses	" 94.05	" 33.50
Sugar	" 98.15	" 83.00

These results were obtained in the same centrifugal machine as above, except the speed of the centrifugal machine was 1,700 R.P.M., and show practically the same results in 25 to 30% less time. These latter stripped samples were run over the 8-board stripping apparatus in use at Wailuku, as were also the following samples, although these were obtained in a 30″ machine, running 1,050 R.P.M. on a very poor quality massecuite.

Brix 93.25 Purity 47.7

212 lbs. unstripped massecuite, spun 1 hr. 30 min. There were
116 lbs. sugar left in the machine, or 54.73%, and
45.27% molasses.

198 lbs. stripped massecuite, spun 1 hr. 8 mins. There were
100 lbs. sugar left in the machine, or 50.51%, and
49.49% molasses—or practically 4% better in 25% less time.

The molasses in both these latter tests was practically the same. In a 98 density massecuite, the improvement varied from 25 to 35%, although I have noticed that the quicker the massecuite is purged after stripping, the better the result.

Regarding the changes that occur to the massecuite due to the stripping process, the Brix was invariably lower after stripping, as was shown by moisture determination, with the spindle and in refractometer tests. The stripped massecuite also runs faster than the unstripped when placed at the same degree of inclination, and appears to have absorbed water, as Dr. R. S. Norris points out, due, probably, to the hydroscopic character of the material.

Also these facts were noticed: the massecuite was invariably warmer after stripping, and had taken up a great deal of air, which characteristic, contrary to the opinion of many sugar men, did not retard its purging.

Regarding the viscosity of the massecuite itself, on tests made through a 2″ pipe from a box, before and after stripping, if the stripped massecuite was warmed by the stripping, even slightly, the viscosity was improved, but if it was cooled while stripping, the viscosity was greater, one degree of temperature affecting it a great deal.

I found also that by letting dry steam circulate around the stripping massecuite, the improvement in its purging qualities was still further increased, but that the steam had to be well regulated, and there was danger of too much heat and too much condensate raising the purity of the resultant molasses; 37° C. seems, from my experiments, to be the danger point in heating the massecuite.

This is, I believe, a simple mechanical method of applying heat cheaply, evenly, and in a limited quantity, to a massecuite before purging, and, I hope, that we have a possibility here of a preparatory treatment of the massecuite by a cheap mechanical device that will save fuel and money by reducing the time of centrifugaling, and will increase the present capacity of our low grade machines, give us a better control of the handling of the massecuite, and a higher remelt product. I believe it is well worth your consideration.